EFFICACY OF FUNGICIDES FOR THE MANAGEMENT OF WHITE MOLD IN SNAP BEAN IN PENNSYLVANIA

FINAL REPORT FOR THE PENNSYLVANIA VEGETABLE MARKETING & RESEARCH PROGRAM
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Summary. A replicated small plot trial was conducted to quantify the efficacy of conventional fungicides (Topsin® 4.5FL, Endura®, and Omega® 500F) and OMRI-listed products (DoubleNickel55™, Serenade® Opti, and Badge X_2) for the control of white mold in snap bean in Pennsylvania. Application of fungicides led to significant reductions in white mold incidence on plants and pods following inoculation with *Sclerotinia sclerotiorum* ascospores. All products significantly reduced disease incidence compared to nontreated control plots. All conventional fungicides tested were highly efficacious and resulted in disease control not significantly different between each other. The similar efficacy of Endura® and Omega® 500F in resistance groups 7 and 29, respectively, offers additional rotational options for ensuring best management practices for minimizing the probability of resistance development to Topsin ® 4.5FL which is frequently chosen by growers because of low cost. Application of DoubleNickel55™ irrespective of rates tested (1.06 and 2.1 quarts/A) provided moderate disease control which was not significantly different from the OMRI-listed copper formulation control, Badge X_2. Serenade® Opti was the least efficacious for the control of white mold of the OMRI-listed products tested. The moderate efficacy of DoubleNickel55™ may provide additional options for the control of white mold within organic snap bean production.

Introduction

White mold, caused by the fungus *Sclerotinia sclerotiorum,* is one of the most devastating and problematic diseases of processing snap bean. The disease is difficult to control due to the: 1) long-lived sclerotia (resting structure of the fungus) produced on diseased plants; 2) wide host range of the pathogen which includes many of the cash crops, cover crops and weeds in typical vegetable rotations; and 3) absence of commercial bean varieties with resistance to *S. sclerotiorum.* In general, agronomic factors susceptible to high yields also exacerbate white mold by promoting canopy development and an ideal environment for disease development. Direct losses from white mold are incurred from reductions in the number of marketable pods. Indirect losses are incurred when the fungus infects the stem causing lodging which makes pods more conducive to white mold and other diseases (e.g. gray mold) and often harder to mechanically harvest. Diseased pods also contribute to the perpetuation and build-up of *S. sclerotiorum* within the field which may serve as inoculum for future susceptible crops.

Fungicides are one of the most critical control measures for white mold in snap bean and management is strongly reliant upon their well-timed use according to flower phenological development. Historically, major changes in the most commonly used fungicides have occurred due to the withdrawal of some products from the market (e.g. Ronilan®) due to health and environmental concerns (Shah et al. 2002). Diversity in efficacious products is also important for rotational purposes to adhere to best management guidelines for fungicide resistance management. The objective of this study was to quantify the efficacy of conventional and OMRI-listed fungicides for white mold management in conventional and organic snap bean production in Pennsylvania.

Materials and Methods

The trial was planted at The New York State Agricultural Experiment Station in Geneva, New York, in a Honeoye silt loam soil (Research North field 25) on 31 May 2016. Seed (var. ‘Huntington’) was planted with a Monosem planter at a rate of 9 seeds/ft. Fertilizer (300 lb/A 15 N: 5 P: 10 K) was banded at planting and the pre-emergent herbicide, Dual Magnum® (1.8 pt/A) was applied on the same day. On 5 July at 35 days after planting (DAP) and growth stage (GS) R1, additional nitrogen (50 lb/A) was applied by hand within the rows. Plant density within each plot was assessed on 5 July by counting the number of plants in a 4 foot section in each of two rows. The trial received supplementary irrigation using overhead sprinklers as required. Growth stage of the snap beans at critical points in the trial was recorded.

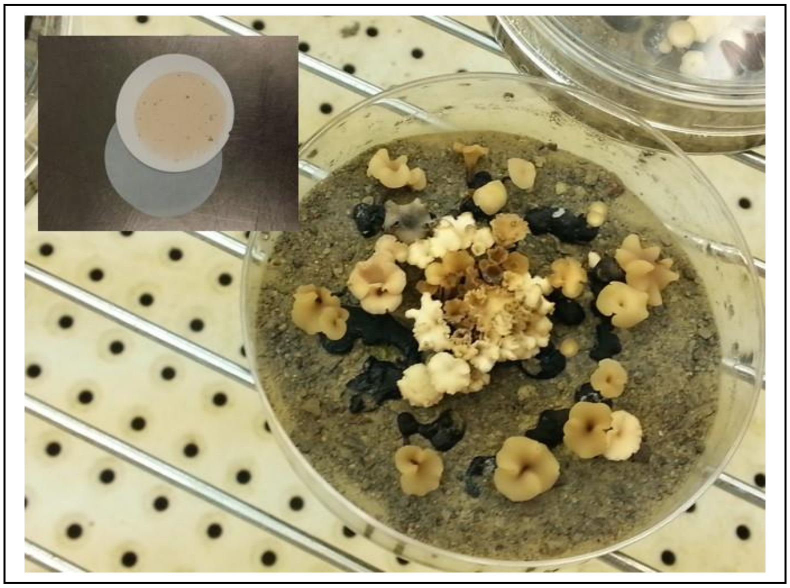
The trial design was a completely randomized block with five replications of each treatment and a nontreated control (Table 1). Each plot was 10 feet long × 2 rows wide. Two noninoculated and nontreated rows separated plots between blocks, and 4-feet sections separated plots within rows. Fungicides were applied with a carbon dioxide-pressurized backpack sprayer with a volume of 26 gallons/A using a 38 inch long boom using four flat fan TJ 8002VS nozzles spaced 19 inches apart on 12 July (~ 10% of plants with at least one open flower [GS = R1]; 42 DAP) and seven days thereafter (~ 100% of plants with at least one open flower [GS = R2]; 49 DAP).

Table 1. Conventional and OMRI-listed products tested for white mold control in snap bean in 2016 at Geneva, New York.

Fungicide (Company)	Active ingredient	FRAC group	Product rate (/A)	Pre-Harvest Interval (days)
Conventional				
Topsin® 4.5FL (UPI)	Thiophanate-methyl	1	30 fl oz	14
Endura® (BASF)	Boscalid	7	11 oz	7
Omega® 500 F (Syngenta)	Fluazinam	29	0.85 pt	14
OMRI-Listed				
Serenade® Opti (Bayer CropScience)	*Bacillus subtilis*	44	18 oz	0
DoubleNickel55™ (Certis USA)	*Bacillus amyloliquefaciens* D747	44	1.06 & 2.1 quarts	0
BadgeX$_2$ (Gowan)	Copper oxychloride + copper hydroxide	M1	2 lb	0

Plots were inoculated with *S. sclerotiorum* ascospores on 14 (44 DAP [GS = R1]), 18 (48 DAP [GS = R1]) and 20 (50 DAP [GS = R3]) July at concentrations of 7.4×10^5, 3.5×10^5, and 1.4×10^5/ml using a backpack sprayer. The germination efficiency of ascospores was at least 98% at each inoculation. Carpogenic germination was induced and ascospores were collected as described by Pethybridge et al. (2015) (Fig 1).

Fig 1. *Sclerotinia sclerotiorum* apothecia and sclerotia in the growth chamber. Ascospores are collected onto filter paper (inset) and stored at -20°C until rehydrated for field inoculations.



The efficacy of fungicides at harvest was assessed on plants from two 3.2-feet sections within each plot on 8 August (69 DAP [GS = R6]) and removing marketable pods by hand (Table 2). Pods and plants were separated into diseased or healthy and the number in each category counted to calculate white mold incidence (%). Plants with white mold had necrotic lesions on stems and often had mycelia and sclerotia present. The weight of the healthy pods was recorded to calculate the average weight of individual healthy pods. The efficacy of fungicides on white mold incidence on pod and plants and yield (weight of healthy pods, and average weight of individual healthy pods) was quantified using generalized linear modelling (Genstat Version 17.1).

Results

Plant density was not significantly different according to treatment allocation across both trials ($P = 0.876$). Disease incidence in the nontreated plots was high with 49.2% and 10.3% of plants and pods, respectively affected by white mold at harvest (Table 2; Fig. 2). The incidence of plants with white mold was significantly reduced by all treatments, however Topsin® 4.5FL, Endura®, Badge X_2, Double Nickel 55™ (2.1 q/A), and Omega® 500 F were the most efficacious and not significantly different from each other. Serenade® Opti was less efficacious than other products tested but still resulted in a significant reduction in the incidence of plants with white mold compared to nontreated plots. The incidence of plants with white mold was not significantly different in plots treated with either rate of Double Nickel 55™ (Table 2).

Fig. 2. White mold in snap bean caused by *Sclerotinia sclerotiorum* on a stem (A) and pod (B) following ascospore inoculations within the small plot replicated trial at Geneva in 2016.

Significant reductions in the incidence of pods with white mold were also obtained from all conventional fungicides tested, with no significant differences between them (Table 2). Applications of Badge X_2 provided moderate disease control that was not significantly different to that obtained by DoubleNickel55™. Serenade® Opti significantly reduced the incidence of white mold in pods and was not significantly different to plots receiving Omega® 500 F, DoubleNickel55™ and Badge X_2 (Table 2). Treatments had no significant effect on the total marketable pod yield and the average weight of a healthy pod (Table 2).

Table 2. Effect of conventional and OMRI-listed products on white mold, marketable yield, and the average weight of a healthy pod in a small plot replicated trial at Geneva in 2016.

Fungicide	Incidence of plants with white mold (%)	Incidence of pods with white mold (%)	Marketable pod yield (g/m)	Average weight of a healthy pod (g)
Topsin® 4.5FL	0.6 e	0.3 d	870	7.9
Endura®	1.9 e	0.9 d	1,177	8.5
Omega® 500 F	7.6 de	2.8 bcd	875	7.9
DoubleNickel55™ (1.06 q/A)	14.7 cd	2.9 bcd	928	8.1
DoubleNickel55™ (2.1 q/A)	10.3 de	1.6 cd	855	7.7
Badge X_2	6.4 de	1.1 cd	915	5.8
Serenade® Opti	32.8 b	5.3 bc	1,015	7.9
Nontreated	49.2 a	10.3 a	817	7.9
Df	44			
LSD	12.4	4.3	-	-
P =	<0.001	<0.001	0.218 (ns)	0.318 (ns)
CV (%)	39.0	25.4	26.2	19.9

Discussion

Inoculation with *S. sclerotiorum* ascospores led to a high incidence of white mold in nontreated plots providing ideal conditions to quantify the efficacy of products available to growers for snap bean production in Pennsylvania. The 'standard' program for pod disease control in conventional snap bean production is one application of Topsin® 4.5FL or Endura® at early bloom (10% flowering) followed by an additional application at 100% flowering approximately 7 to 10 days thereafter. Topsin® 4.5FL has been commonly used since the withdrawal of Ronilan® (vinclozolin) in 2005 (Shah *et al.,* 2002). The active ingredient of Topsin® 4.5FL (thiophanate-methyl) belongs to FRAC group 1 and consequently has a high risk of resistance development. Omega® 500 F (FRAC group 29) and Endura® (FRAC group 7) offer rotational advantages with no significant difference in disease control. The widespread adoption of Endura® by growers is limited by high cost. Omega® 500 F is a newly registered on a range of crops, including snap beans in Pennsylvania, providing a valuable rotational option for conventional growers.

Applications of DoubleNickel55™ (2.1 quarts/A) resulted in reductions in the incidence of plants (81%) and pods (85%) with white mold compared to the nontreated plots. Moreover, disease control was not significantly reduced by halving the rate of DoubleNickel55™. DoubleNickel55™ is a biofungicide containing the bacterium, *Bacillus amyloliquefaciens* D747 strain and is registered as approved for organic production by the National Organic Program and approved for use in certified organic vegetable production by the Organic Materials Review Institute. In contrast, relatively poorer control of white mold on pods and plants was obtained using Serenade® Opti which contains the bacterium, *Bacillus subtilis*. Disease control using the OMRI-registered copper formulation, Badge X_2 was not significantly different to either rate of DoubleNickel55™. This finding may assist in the control of white mold in organic snap bean production in Pennsylvania.

Extension of findings. A fact sheet is available for distribution at local meetings. Presentations will be conducted as requested.

A final expenditure report, courtesy of Ms. Janice Valerio, Finance Manager, is provided below:

Field Research Unit Charges	$ 384
Greenhouse Charges	$ 668
Cornell BioTech Charges	$ 330
Materials & Supplies	$ 2,904
Salaries	$ 3,390
Total funding spent	**$ 7,676**

References

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2. Shah, D. A., Dillard, H. R., and Cobb, A. C. 2002. Alternatives to vinclozolin (Ronilan) for controlling gray and white mold on snap bean pods in New York. Online. Plant Health Progress. doi:10.1094/PHP-2002-0923-01-RS.